Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 2

Wednesday 4 May 2016 (morning)

Candidate session number

2 hours 15 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer two questions.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[72 marks]**.

2216 – 6002
© International Baccalaureate Organization 2016

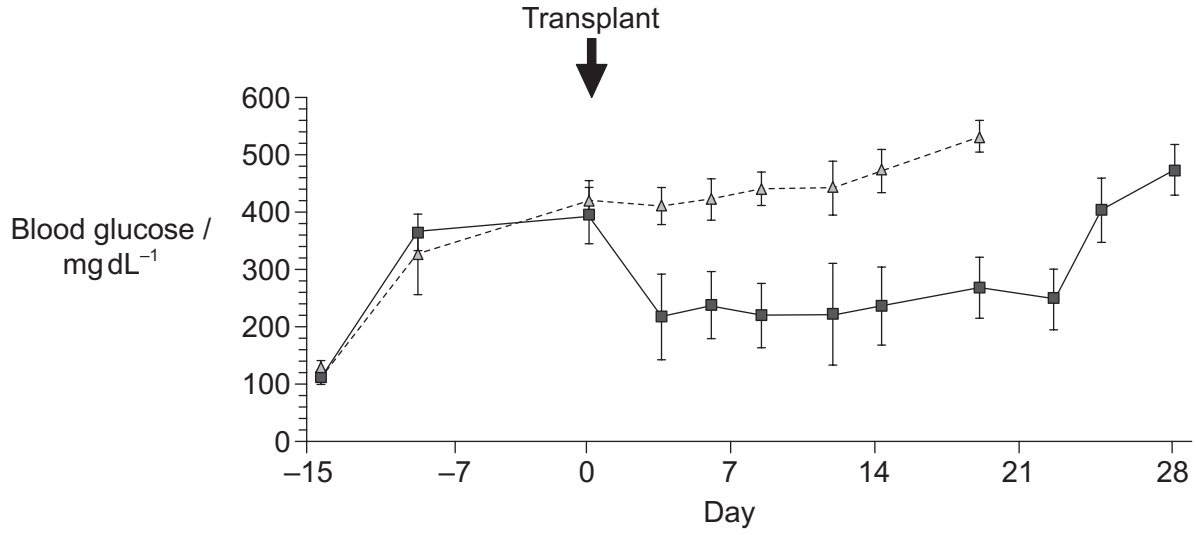
International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

Section A

Answer **all** questions. Write your answers in the boxes provided.

1. Type I diabetes is a leading cause of death in advanced countries and is associated with various severe or fatal complications, including blindness, kidney failure, heart disease, stroke, neuropathy, and amputations. Embryonic stem cells are considered to be a powerful tool in the treatment of diabetes.

In a study, embryonic stem cells were grown in culture and tested for insulin mRNA. A drug was injected into two groups of healthy mice in order to simulate type I diabetes 15 days prior to the transplant of embryonic stem cells. The mice in the transplant group received embryonic stem cells that produce insulin mRNA. The control group did not receive the transplant. The graph shows the blood glucose concentration in both groups.



[Source: Reprinted from *The American Journal of Pathology*, Vol 106, no. 6, Takahisa Fujikawa *et al.*, "Teratoma Formation Leads to Failure of Treatment for Type I Diabetes Using Embryonic Stem Cell-Derived Insulin-Producing Cells", pp. 1781–1791, Copyright © 2005 American Society for Investigative Pathology. Published by Elsevier Inc. All rights reserved.]

(a) State the highest mean concentration of blood glucose in the mice with transplants. [1]

. . . . . mg dL^{-1}

(This question continues on the following page)

(Question 1 continued)

(b) Outline the cause of type I diabetes in humans. [1]

. . . . . .
. . . . . .

(c) Describe the reason for testing for insulin mRNA in the embryonic stem cell cultures. [1]

. . . . . .
. . . . . .

(d) Compare and contrast the concentration of blood glucose resulting from the embryonic stem cell transplant with the control. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(e) Evaluate the effectiveness of the embryonic stem cell treatment in controlling blood glucose. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(This question continues on the following page)

(Question 1 continued)

In a second study, a group of patients recently diagnosed with type I diabetes received a transplant of stem cells. Based on their need for insulin after the transplant, participants were divided into two groups. Their C-peptide production levels were measured for 24 months as the levels indicate the degree of pancreatic beta-cell function. Group 1 did not require insulin and group 2 required insulin occasionally during the study. The graphs show the levels of C-peptides in each individual of both groups 1 and 2.

Graphs removed for copyright reasons

(f) State the highest rate of production of C-peptides after 24 months in group 2. [1]

. . . . . ng ml^{-1} $2h^{-1}$

(This question continues on the following page)

(Question 1 continued)

(g) Insulin is produced by cutting C-peptide from the precursor molecule proinsulin. Suggest why group 1 has a greater level of C-peptide than group 2. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

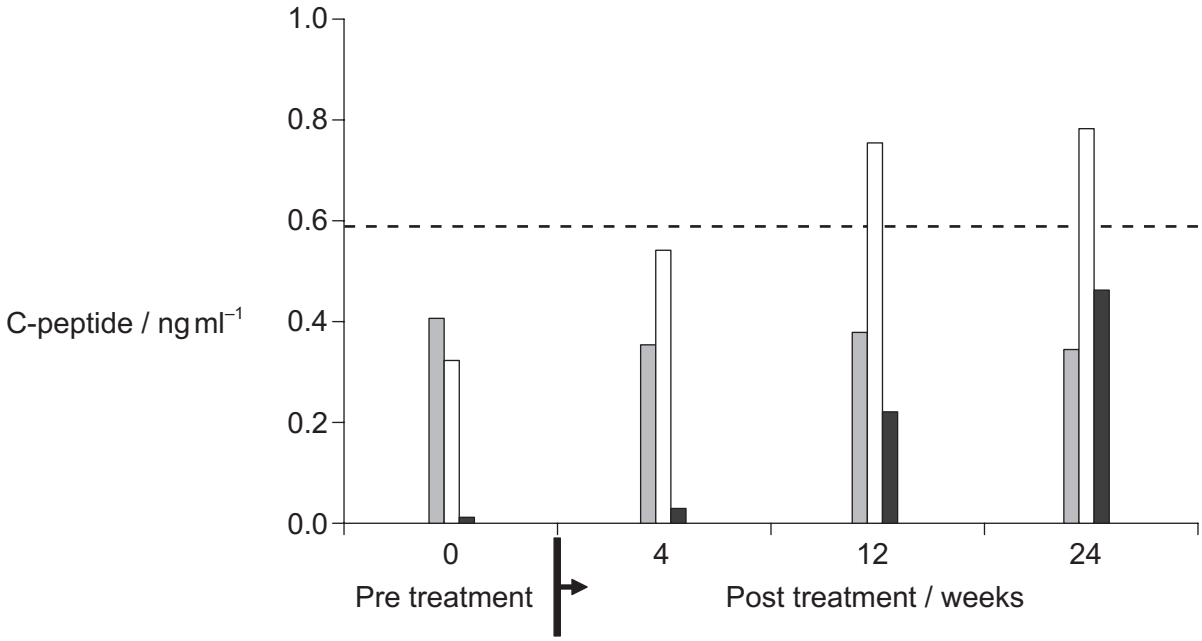
. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

A few years later, a third study used a treatment with umbilical cord stem cells on patients who had suffered from moderate or severe type I diabetes for an average of 8 years. They were divided into two groups: group 1 had moderate diabetes and group 2 had severe diabetes. The patients' blood was circulated outside the body and exposed to umbilical cord stem cells before returning to the patients' circulation. The control group had moderate diabetes and received the same treatment but without umbilical cord stem cells.



Key: control group moderate, no exposure
group 1 moderate, exposure to stem cells
lower limit for normal C-peptide
group 2 severe, exposure to stem cells

[Source: doi:10.1186/1741-7015-10-3
Zhao *et al.*: Reversal of type 1 diabetes via islet ß cell regeneration following immune modulation by cord blood-derived multipotent stem cells. *BMC Medicine* 2012 10:3.]

(This question continues on the following page)

(Question 1 continued)

(h) Compare and contrast the results of the treatment on group 1 with the results of the treatment on group 2. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

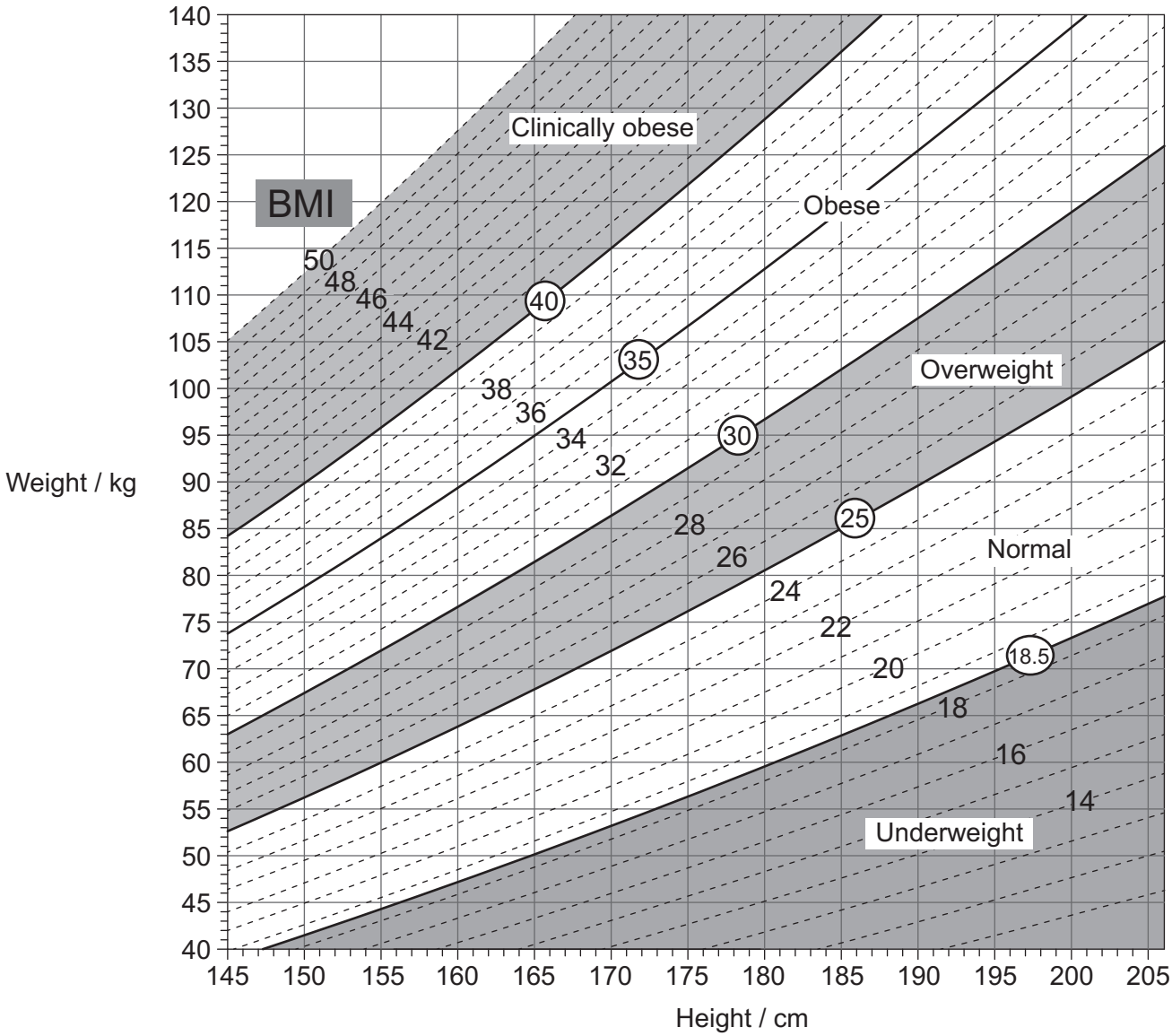
(i) Suggest an ethical advantage of using this type of therapy over embryonic stem cell therapy. [1]

. . . . . .
. . . . . .

(j) Using the data from all three studies, evaluate the use of embryonic stem cells as a treatment for type I diabetes. [4]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

2. The image shows a nomogram.



[Source: © All rights reserved. *Canadian Guidelines for Body Weight Classification in Adults*. Health Canada, 2003. Adapted and reproduced with permission from the Minister of Health, 2016.]

(a) (i) Using the nomogram, state the lower weight limit for a woman with the height of 155 cm who is classified as overweight, giving the units. [1]

Lower weight limit: . . . . . .

(This question continues on the following page)

(Question 2 continued)

(ii) State a major health problem of the circulatory system that is correlated with obesity. [1]

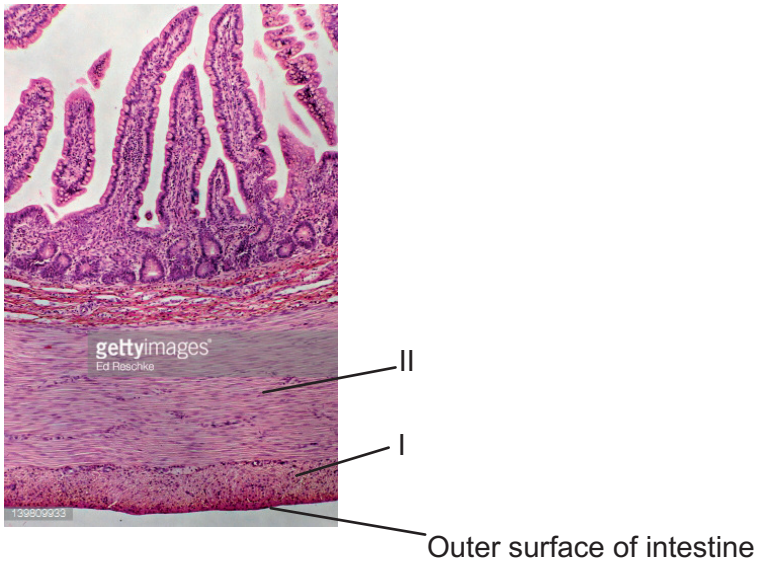
. . . . . .
. . . . . .

(b) Draw the structure of a saturated fatty acid. [2]

(c) Describe how the hormone leptin helps to prevent obesity. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

3. The image shows a transverse section of an intestinal wall at 100× magnification.



[Source: Ed Reschke/Getty Images]

(a) Identify the tissues labelled I and II on the image. [2]

I: . . . . . .

II: . . . . . .

(b) All motor neurons use acetylcholine to activate skeletal muscle. Explain the effect of neonicotinoid pesticides in insect synapses in the central nervous system. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

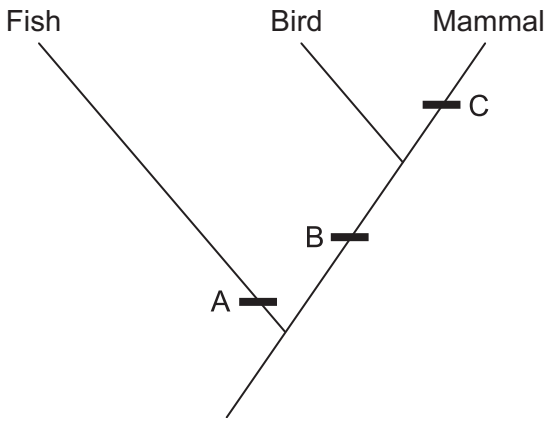
(This question continues on the following page)

(Question 3 continued)

(c) Resistance to neonicotinoid pesticides has been observed in some insects.
Describe briefly how this resistance could have arisen in populations of insects. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

4. The image shows part of a cladogram.



(a) Using the cladogram, identify **one** diagnostic feature that characterizes the given groups of vertebrates at A, B and C. [3]

A: . . . . . .

B: . . . . . .

C: . . . . . .

(b) Starting from the concept of gene pool, explain briefly how populations of early vertebrates could have evolved into different groups. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 4 continued)

(c) Mitochondria are thought to have evolved from prokaryotic cells. Describe **two** adaptations of the mitochondria, each related to its function. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Section B

Answer **two** questions. Up to one additional mark is available for the construction of your answers for each question. Write your answers in the boxes provided.

5. (a) Outline the action of enzymes. [4]

(b) Explain the roles of specific enzymes in prokaryote DNA replication. [7]

(c) Many genetic diseases are due to recessive alleles of autosomal genes that code for an enzyme. Using a Punnett grid, explain how parents who do not show signs of such a disease can produce a child with the disease. [4]

6. (a) Draw a labelled diagram that shows the positions of proteins within the cell membrane. [3]

(b) Outline the effects of putting plant tissue in a hypertonic solution. [4]

(c) Explain how the structure of the nephron and its associated blood vessels enable the kidney to carry out its functions. [8]

7. (a) Draw a labelled diagram of a eukaryotic plant cell as seen in an electron micrograph. [4]

(b) Outline how the energy flow through food chains limits their length. [3]

(c) In hot, dry conditions plants lose water rapidly due to transpiration. Explain how the structures and processes of the plant allow this water to be replaced. [8]